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ABSTRACT

This report is the second in a series of reports presenting analyses and discussion of data on body measurements performed in Cycle III of the Health Examination Survey. The method employed for the study, which involved physical examinations of youths at mobile examination centers at 40 preselected locations throughout the country, is described in detail. There is a description of the results which presents data comparing height, weight, stature, and sitting height with reference to age and race. The appendixes include 12 supportive statistical tables and statistical notes on the design of the study. (JA)

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Data from the
NATIONAL HEALTH SURVEY

Series 11
Number 126

Body Weight, Stature, and Sitting Height: White and Negro Youths 12-17 Years United States

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Height, weight, and sitting height measurements on white and Negro youths 12-17 years of age in the United States, 1966-70, are compared.

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In accordance with specifications established by the National Health Survey, the Bureau of the Census, under a contractual agreement, participated in the design and selection of the sample, and carried out the first stage of the field interviewing and certain parts of the statistical processing.

Vital and Health Statistics-Series 11-No. 126

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BODY WEIGHT, STATURE, AND SITTING HEIGHT: WHITE AND NEGRO YOUTHS 12-17 YEARS

Peter V. V. Hamill, M.D., M.P.H., Francis E. Johnston, Ph.D.
and Stanley Lemeshow, M.S.P.H.[a]

INTRODUCTION

This report comparing the weights, standing heights, and sitting heights of white and Negro youths 12-17 years of age in the United States is the second one in a series of reports presenting analyses and discussion of data on body measurements performed in Cycle III of the Health Examination Survey. The first report[1] also concerned height and weight, but it focused on the interpretation of data during the adolescent growth spurt and on clinical standards. This series of Cycle III reports will parallel the series on body measurement data from Cycle II on children 6-11 years of age which covers heights, weights, skinfolds, and more than 20 other body dimensions related to variables such as age, sex, race, geographic region, socioeconomic level of family, IQ, self-concept, school achievement, and skeletal age. These reports of Cycle III body measurements, by supplementing the reports from Cycles I and II, complete the publication of data reporting body measurements for the population 6-79 years of age in the United States in the decade of the 1960's.

Cycle I of the Health Examination Survey (HES), conducted from 1959 to 1962, obtained information on the prevalence of certain chronic diseases and on the distribution of a number of anthropometric and sensory characteristics in the civilian, noninstitutionalized population of the continental United States aged 18-79 years. The general plan and operation of the survey and of Cycle I are described in two previous reports[2,3] and most of the results are published in other *Vital and Health Statistics* Series 11 reports.

Cycle II of the Health Examination Survey, conducted from July 1963 to December 1965, involved selection and examination of a probability sample of noninstitutionalized children in the United States aged 6-11 years. This program succeeded in examining 96 percent of the 7,417 children selected for the sample. The examination had two focuses: on factors related to healthy growth and development as determined by a physician, a nurse, a dentist, and a psychologist and on a variety of somatic and physiologic measurements performed by specially trained technicians. The detailed plan and operation of Cycle II and the response results are described in *Vital and Health Statistics*, Series 1-Number 5.[4]

HES Cycle III, conducted from March 1966 to March 1970, was essentially an agewise extension of Cycle II. As described in detail in "Plan and Operation of a Health Examination Survey of U.S. Youths 12-17 Years of Age,"[5] it was more similar to Cycle II than it was to Cycle I not only in form, content, and style but also with its major emphasis on factors of "normal" growth and development rather than chronic diseases. In fact, the identical sampling units were used in Cycle III which had been used in Cycle

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II approximately 3 years earlier,[b] and as a result over 30 percent of the youths examined in Cycle III had also been examined as children in Cycle II 3 years earlier. By examining more than 2,000 of the children at two different ages, it was intended to provide a quasi-longitudinal aspect to these two sequential cross-sectional surveys. However, this more complex quasi-longitudinal analysis will be reserved for future reports on body composition and body proportion; in this report the data will be handled in the more familiar *cross-sectional mode.*

The first report from Cycle III, Series 11, Number 124,[1] presented data on measurements of height and weight by age and sex and focused on two facets: (1) the adolescent growth spurt and (2) a discussion of clinical application of the data and presentation of clinical standards. This report carries the analysis of height and weight data a step further not only by introducing race as the major classifying variable but also by taking a more detailed look at stature through analysis of the reciprocal relationship of its major components, sitting height and leg length. The adolescent growth spurts of Negro and white youths will be compared by examining peaks of the pseudo velocity curves. The reader is referred to the first report, Number 124,[1] for the extensive discussion of problems inherent in examining cross-sectional data taken during the growth spurt. Of course, the same inferential limitations pertain to this report.

Parallel to the pattern of the series of reports on body measurements on children, the subsequent reports on youths 12-17 years of age will become increasingly analytic. Analysis by socioeconomic level of family, by geographic differences in the United States, by "biologic age,"[c] by other body dimensions, and by physiologic and behavioral variables will be subjects of subsequent reports. In this report the data are presented by percentile distributions and by means and standard errors; the ages are grouped both by 1-year and by 6-month age intervals[d] in an attempt to balance increasing "statistical noise" resulting from smaller samples on the one hand with the finer precision in pinpointing, in time, deflections of curves on the other hand.

METHOD

At each of 40 preselected locations (see appendix for sample design) throughout the United States, the youths were brought to the centrally located mobile examination center for an examination which lasted about 3½ hours. Six youths were examined in the morning and six in the afternoon. Except during vacations, they were transported to and from school and/or home.

When they entered the examination center, each youth's oral temperature was taken and a cursory screening for acute illness was made; if illness was detected, the youth was sent home and reexamined later. The examinees changed into gymnasium-type shorts; cotton sweat socks; a terry cloth robe; and, for the girls, a light sleeveless topper. All six then proceeded to different stages of the examination, each one following a different route. The 3½-hour examination was divided into six 35-minute time periods, each consisting of one or more detailed examinations at a designated station. At the end of each period the youths rotated to another station so that at the end of 3½ hours each youth had had essentially the same examinations by the same examiners but in a different sequence. Four of these examination time periods were allocated to examinations by a pediatrician, a dentist, and a psychologist,[e] and the other two were

[b] In Cycle II two separate caravans were used simultaneously for the first 25 locations: the two were then consolidated into one caravan for the remaining 15 locations. In Cycle III only one caravan was used for all 40 locations, which created a different itinerary or sequence of locations around the United States even though the identical sites and even primary sampling units were used again. The average time interval between locations was about 3 years.

[c] "Biologic age" will be estimated primarily by skeletal age and by maturation level of primary and secondary sex characteristics as assessed by the examining physician.

[d] In the first report, Series 11, Number 124, when sex was the only additional classification, the ages were divided into 3-month age intervals, but the small size of the Negro sample precludes this when race is the principal classification.

[e] The entire examination by the psychologists consisted of two consecutive time periods (70 minutes). Two psychologists performed identical examinations simultaneously at separate stations.

allocated to a group of examinations performed by highly trained technicians. This last group of examinations consisted of X-rays of the chest and hand-wrist, hearing and vision tests, measures of respiratory function, a 12-lead electrocardiogram, a submaximal exercise tolerance test on a treadmill with chest leads to a continuous electrocardiogram, a battery of body measurements, grip strength, examination of blood and (on girls only) urine cultures for bacteria, and a privately administered health behavior and attitude questionnaire.

The measurements of height and weight were obtained exactly as described for children 6-11 years of age.[6]

Height

Height was measured in stocking feet, with feet together, back and heels against the upright bar of the height scale, head approximately in the Frankfort horizontal plane ("look straight ahead"), and standing erect ("stand up tall" or "stand up real straight" with some assistance and demonstration when necessary).[f] However, upward pressure was not exerted by the examiner on the subjects' mastoid processes to purposefully "stretch everyone in a standard manner" as recommended by some.[7] It is reported that supine length, that is, the recumbent position, which relieves gravitational compression of the intervertebral discs, exceeds standing height by approximately 2 centimeters (cm.) and that with the "upward pressure technique" the difference is about 1 cm. greater than with the HES technique.[8]

The equipment consisted of a level platform to which was attached a vertical bar with a steel tape. Attached to another bar in the same plane as the horizontal measuring bar was a Polaroid camera which recorded the subject's identification number next to the pointer on the scale giving a precise reading. The camera, of course, not only gave a permanent record minimizing observer and recording error but, by sliding up and down with a horizontal bar and always being in the same plane, also eliminated parallax. That is, if the pointer had been in the space in front of the scale, it would have been read too high if the observer had looked up at the scale from below, or too low if read down from above.

Weight

A Toledo self-balancing weight scale that mechanically printed the weight to a tenth of a pound directly onto the permanent record was used. This direct printing was used to minimize observer and recording errors. The scale was calibrated with a set of known weights, and any necessary fine adjustments were made at the beginning of each new trailer location, i.e., approximately every month. The recorded weight was later transferred to a punched card to the nearest 0.5 pound (lb.). The total weights of all clothing worn ranged from 0.24 to 0.66 lb.; this has not been deducted from weights presented in this report. (The weights, then, are 0.24-0.66 lb. above nude weight recorded to the nearest 0.5 lb.) The examination clothing used was the same throughout the year so there is no seasonal variation in the weight of clothing. These efforts in quality control appear justified by the excellent level of reproducibility of measurements.

Sitting Height

All sitting measurements were taken in a systematic manner. The youth sat on the measuring table with the popliteal fossae at the front edge of the table. The footrest was adjusted so that the youth sat with his knees and feet together, with heels against the heel rests, with the feet at right angles to the lower legs, and with the lower legs at right angles to the thighs. Elbows were held at the sides with forearms at right angles and hands open (palms facing each other). Arm positions were adjusted when necessary to meet the requirements of specific measurements.

Sitting height was measured as the vertical distance from the sitting surface to the top of the head. With the subject seated erectly with head in the Frankfort plane, as described above, the backboard on the measuring table was brought firmly against the buttocks. The movable arm of the anthropometer (which was inserted into the backboard) was brought down *firmly* to the midline of the top of the head.

[f] This is the standard erect position described by Krogman.[8]

Age

As in all the HES reports, age is basically defined as age attained at last birthday (obtained from a copy of the birth certificate in 92 percent of the Cycle III examinees). In all tables utilizing 1-year age groupings, the designated age represents the beginning of the interval and not the mean age of the group (i.e., "15 years" means 15.0 to 15.99 years). However, when the population is divided into half-year age groupings, the designated age is the approximate mean of the age group (e.g., the group designated 15½ years in table 2 includes all those youths 15½ years ±3 months or 15.25-15.74 years with exact means of 15.49 years for boys and 15.51 years for girls).

Race

Race was recorded as "white," "Negro," and "other races."[8] In Cycle III, the white youths constituted 84.74 percent of the total, the Negro youths 14.76 percent, and youths of other races only 0.50 percent. In Cycle II white youths constituted 85.69 percent of the examined subjects and Negro youths 13.86 percent. (The differential response rate by age, sex, and race is analyzed and discussed on page 28 of the appendix. The increased proportion of Negro subjects in Cycle III was due to their better response rate—the overall Negro response rate was 96.6 percent and the overall white response rate was 89.1 percent.) As in Cycle II, because so few youths of "other races" were part of the sample, data from them have not been analyzed as a separate category. Their data, of course, are included whenever data are analyzed independently of a classification by race (as in the previous report, Series 11, Number 124[1]—in which the data were classified by age and sex only).

Report Number 124 initiated the inclusion of data from a previous HES cycle. In all the reports of HES data to that time, the data from each cycle had been handled as a discrete age group. However, the overlapping sampling design and similar methodology of Cycles II and III permit the height and weight data of children 6-11 years of age to be incorporated in many of the figures and some of the tables in this present series of reports to give a much better perspective of the adolescent growth spurt by describing the 12-year span, 6-17 years, rather than restricting to ages 12-17.

RESULTS

Table 1 presents mean height in centimeters, standard deviation, standard error of the mean, and seven selected percentiles, separately, for whites and Negroes, by age at last birthday (whole-year age groups), in the United States, 1966-70. Table 2 presents the same information grouped by half-year age intervals for white boys and girls, while table 3 uses the identical format for Negro boys and girls.

When the data from these tables are presented in graphs, the correlative data from Cycle II, on children 6-11 years of age, have been added to give a better perspective.

Figure 1, comparing the boys' relative mean heights from the data in tables 2 and 3, is rather difficult to interpret. The curve of the white boys' mean heights is quite smooth; but the curve of the Negro boys, whose sample size is only about 15 percent as large, fluctuates around the more stable curve so erratically that an inference comparing the heights is impossible. Figure 2, however, is clearer. It graphs data from tables 4 and 5 and compares the mean heights of the half-year age groups of Negro and white boys which have been *smoothed by a 3-period moving average*, the same technique discussed and employed extensively in Series 11, Number

[8]The same classification scheme as used in the 1960 census was employed here. As described in the previously mentioned report on the operation of HES Cycle III,[5] this information was obtained at the initial household interview by the Bureau of the Census field worker. Its accuracy was checked at the subsequent home visit by the highly experienced representative from HES and again at the examination in the trailer. A final record check by birth certificate turned up only seven inconsistencies, and these were mostly pertaining to the category, "other races." Hence, the possible extent of misclassification of the variable, race, as described, is so minimal that it could have no effect on the data analyzed in this report. However, when comparing the present HES findings to those of other variously defined racial groupings in the world, the degrees of genetic admixture, as first discussed by Herskowitz[9] in 1928 and later by Glass and Li,[10] by Roberts,[11,12] and by Reed,[13] should be taken into consideration.

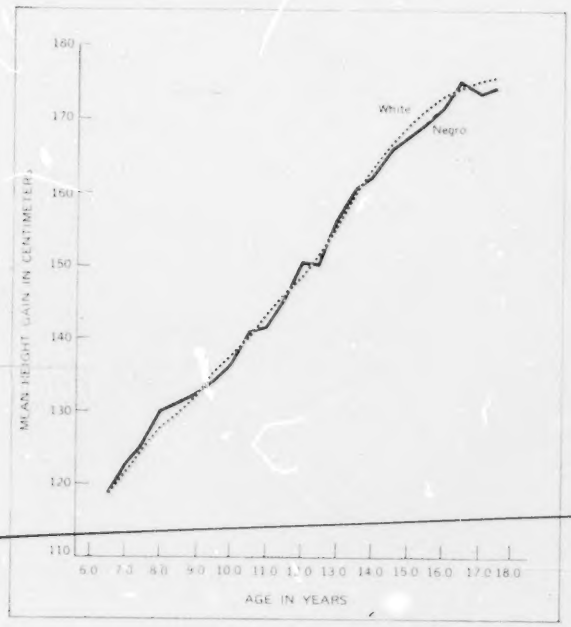

Figure 1. Distance curve of mean height attained by males 6-18 years of age, by half-year age group and race.

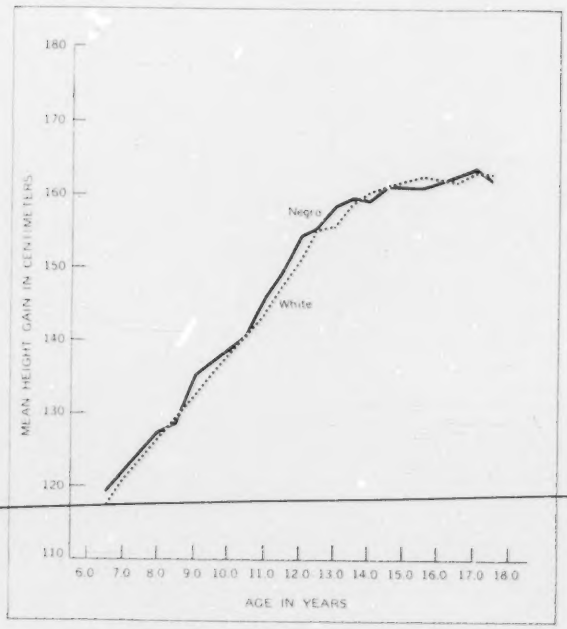

Figure 3. Distance curve of mean height attained by females 6-18 years of age, by half-year age group and race.

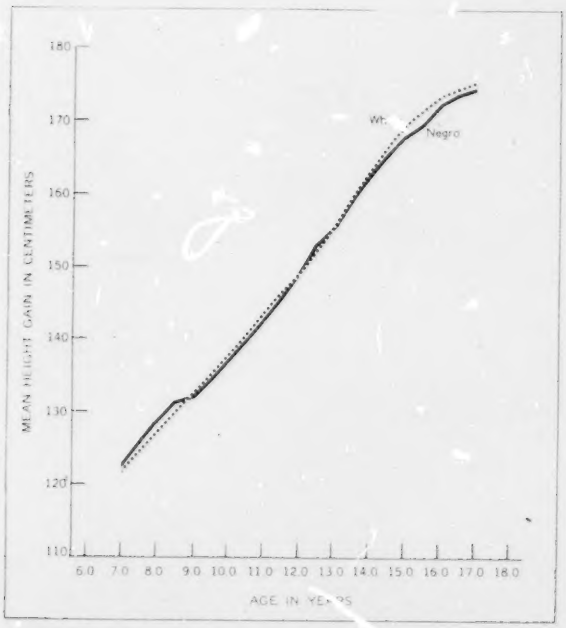

Figure 2. Distance curve of mean height attained by males 6-18 years of age, by half-year age group (smoothed by a 3-period moving average) and race.

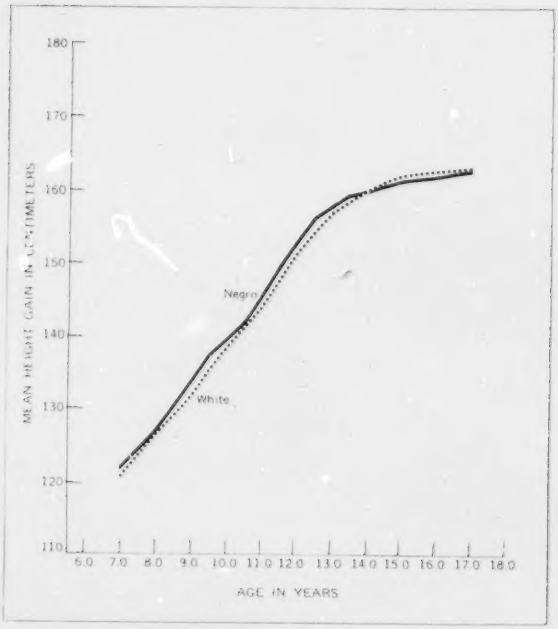

Figure 4. Distance curve of mean height attained by females 6-18 years of age, by half-year age group (smoothed by a 3-period moving average) and race.

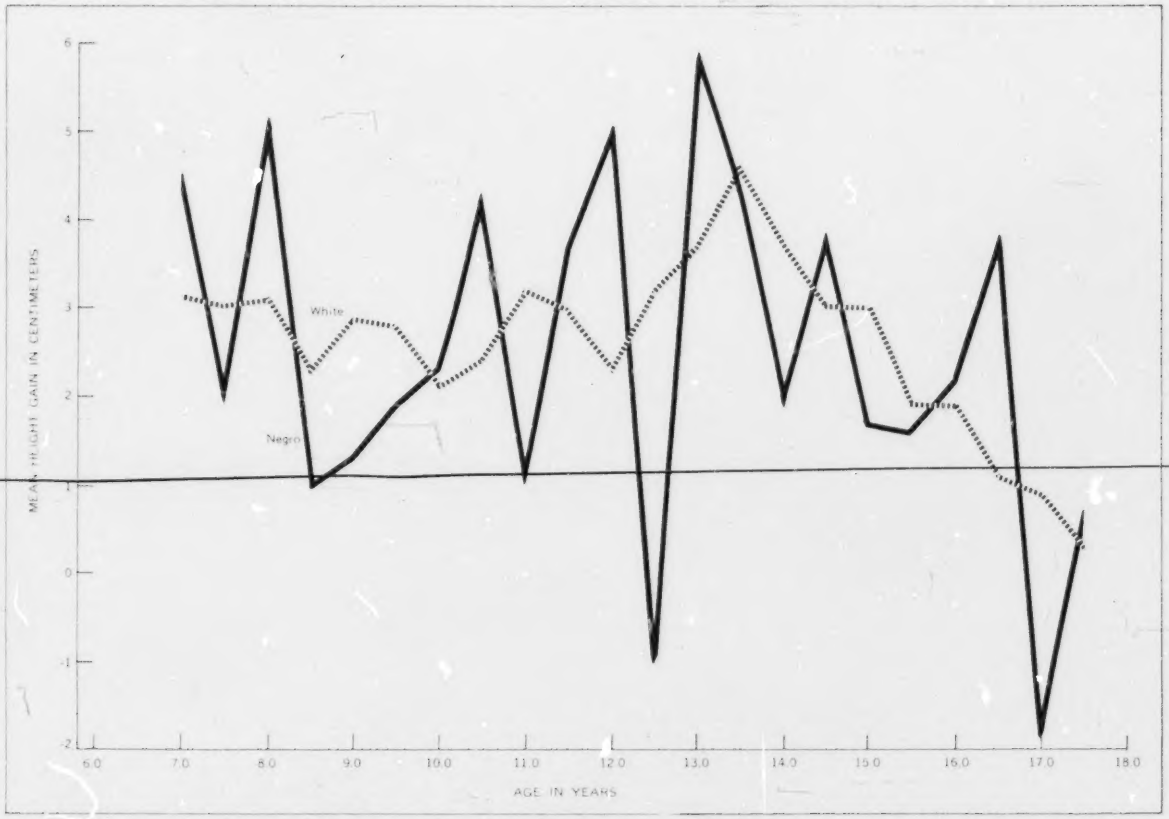

Figure 5. Pseudo velocity curve of differences in mean heights between successive groups of males 6-18 years of age, by half-year age group and race.

124. A comparison of figures 1 and 2 illustrates the advantage of smoothing the means when using small samples (i.e., the sample sizes of the half-year age groupings of Negro boys ranged from 19 to 53). The graphs in figure 2 indicate that the Negro boys were taller at ages 7-9 years, the white boys were slightly taller from 9 to approximately 12 years. These two groups of boys had virtually identical mean heights from 12-14 years, and from 14-17 years the mean heights of the white boys were slightly—but consistently—greater than those of their Negro counterparts.

Figure 3, which graphs the girls' data from tables 2 and 3, is as difficult to interpret as the corresponding graphs for the boys (figure 1). Figure 4, which graphs the smoothed means of the half-year age groupings of girls (tables 4 and 5), shows rather clearly that the mean heights of Negro girls are consistently greater than those of white girls from 7 years until 14 years of age. From ages 14 until 17 the mean heights of the white girls become slightly, but consistently, greater.

The differences in boys' mean heights between the successive half-year age groups are graphed to create pseudo velocity curves (as described in the first report, Number 124[1]).It can be seen that figure 5 has so much noise (such erratic swings from point to point in the much smaller sample size of Negroes) that it is utterly unreadable. Therefore, the means were smoothed by the moving average technique, and the differences between successive age means obtained in this way are plotted in figure 6. Of the four parameters of the adolescent growth spurt discussed in report Number 124, the only one which has enough stability to be useful in this report is the age at peak velocity. It is apparent that the peaks of both the white and the Negro

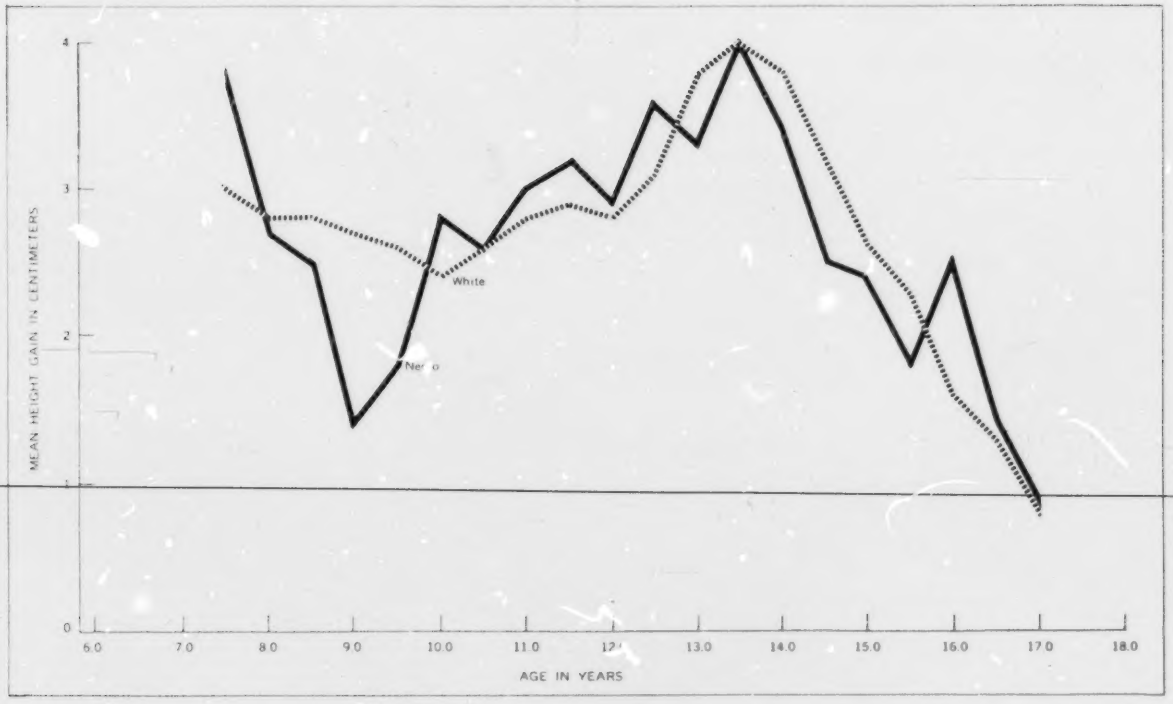

Figure 6. Pseudo velocity curve of differences in mean heights between successive groups of males 6-18 years of age, by half-year age group (smoothed by a 3-period moving average) and race.

boys' pseudo velocity curves are identical, both by chronological placement and in magnitude. And, of course, the two peaks in figure 6 are located at the same age, 13¼ years, as it was for all boys—regardless of race—in report Number 124.

When the Negro girls and white girls are compared similarly (figures 7 and 8), it is readily seen that the peak height velocity for Negro girls is of greater relative magnitude and occurs one-half year earlier (i.e., at 11¼ years of age for Negro girls and at 11¾ years[h] for white girls).

Weight

The weights of white and Negro youths are compared in the same way that heights are. There are two inherent differences between the height data and the weight data, however. The distribution of height data is essentially gaussian (i.e., a normal distribution), while weight data are skewed to the right (i.e., high weight values stray further from the median than do low values), and both individuals and populations vary more in weight than in height. Tables 6-10 present the weight data in a manner similar to that in which heights are presented (i.e., table 6 arranges weight data in kilograms by 1-year age intervals, while tables 7 and 8 subdivide the age groupings by half-year intervals). Only mean weights smoothed by a 3-period moving average are presented in graphs (data from tables 9 and 10).

Figure 9, comparing white and Negro boys by weight, shows that the mean weights of Negro boys are less than those of white boys at all ages except at 13, 13½, and 14 years and the differences are much greater from 14-17 years than at any earlier ages; however, it is greatest at age 15 and apparently is not so great at 16 and 17 years.

The comparative peak weight velocities for boys from the pseudo weight velocity curves in

[h]In report Number 124, the peak height velocity for all races of U.S. girls combined was 11¾ years.

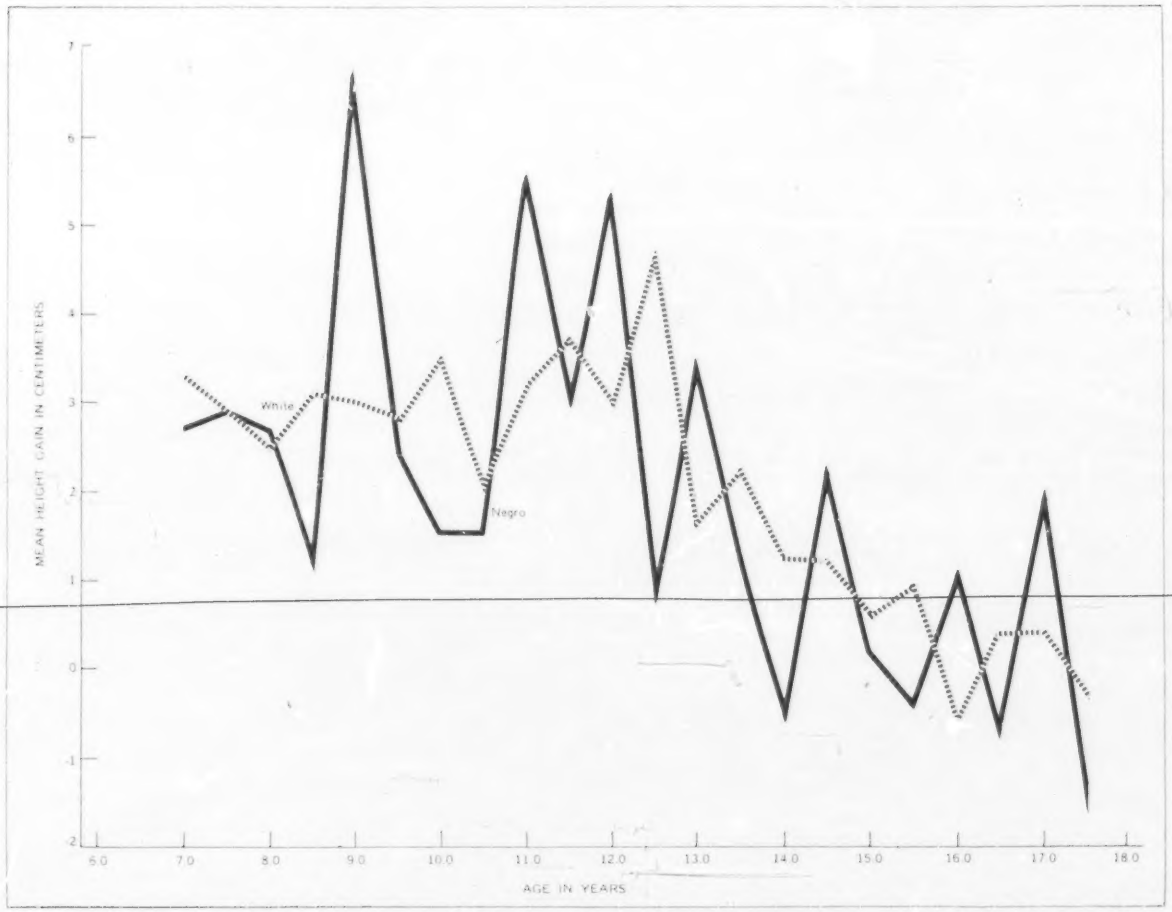

Figure 7. Pseudo velocity curve of differences in mean heights between successive groups of females 6-18 years of age, by half-year age group and race.

figure 10 do not peak as sharply or as clearly as did those for height. However, despite erratic movement at the peaks of the curves, a common peak is barely discernible at 13¾ years. (This is the same age at which boys of all races combined had the peak weight velocity for the smoothed half-year age group in report Number 124.)

As seen in figure 11, the mean weights of Negro girls are greater than those of white girls from ages 11-15 years. After age 15, however, there are no consistent differences between the mean weights of the two groups of girls. In comparing the mean ages at peak weight velocity in figure 12, the Negro girls hit a peak at 11¼ years, fully 1 year ahead of the white girls' peak at 12¼ years. The relative magnitude of the peak weight velocity is also greater for Negro girls (as it is for heights).

Sitting Height/Stature Ratio

Stature (total standing height) is composed of two major segments: sitting height and leg length. Table 11 presents sitting height while table 12 presents the percentage of stature accounted for by the sitting height segment arranged by the mean percentages of each 1-year age grouping separately for males (white vs. Negro) and females (white vs. Negro) together with the standard deviations, the standard errors of the means, and seven percentile distributions.

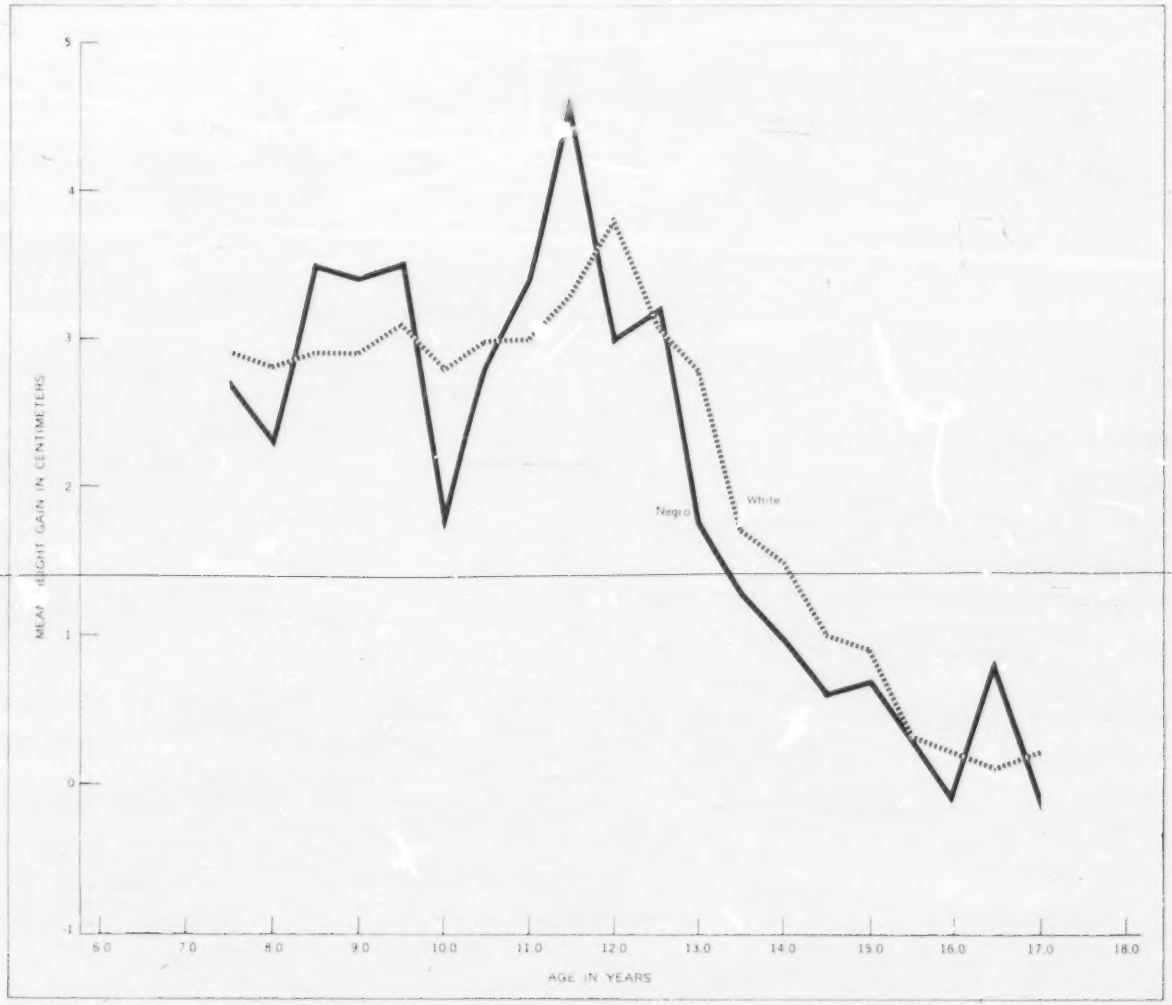

Figure 8. Pseudo velocity curve of differences in mean heights between successive groups of females 6-18 years of age, by half-year age group (smoothed by a 3-period moving average) and race.

Figure 13 graphs these mean sitting height/stature percentages, by each year of age 12-17 years, for all four sex-race groups of youths.

All four lines slope upward with age which indicates that sitting height constitutes an increasingly large proportion of stature with each year of adolescence. Also, the four lines are almost parallel indicating that the differences between the four groups remain approximately consistent, or, in other words, the proportionate increase of sitting height is similar for all four groups.

In addition to the age gradient there is a strikingly consistent sex difference. The girls of each race have a greater proportionate sitting height than do the respective boys—and by about the same magnitude.

However, the racial differences are even more striking than the sex differences: i.e., the sitting height/stature ratio of the white girls has a greater margin of difference over that of the Negro girls than it has over that of the white boys; and, as a corollary, the white boys' sitting height ratio has a much greater margin over that

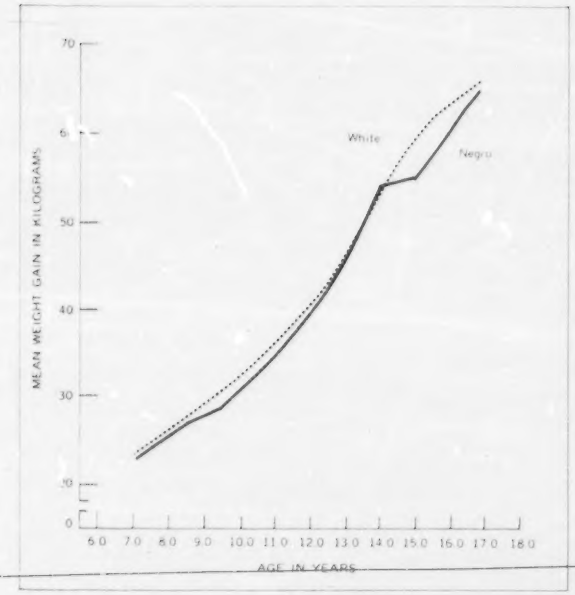

Figure 9. Distance curve of mean weight attained by males 6-18 years of age, by half-year age group (smoothed by a 3-period moving average) and race.

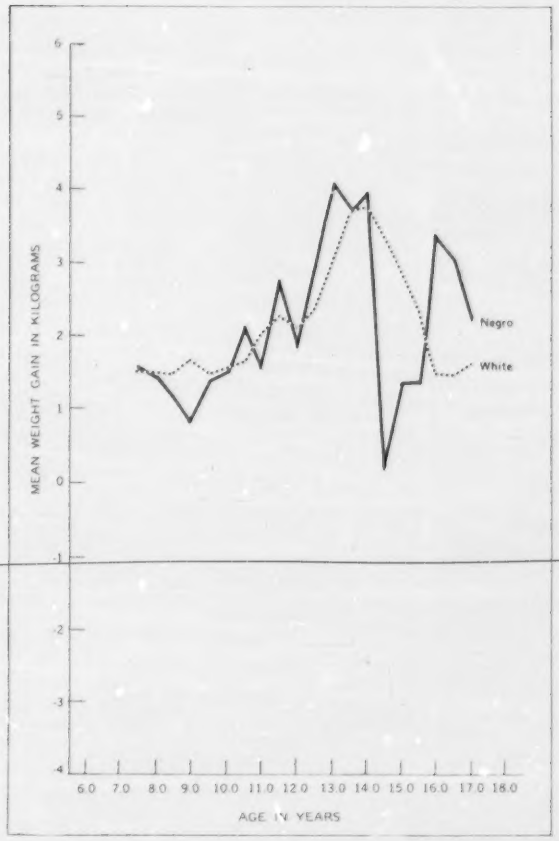

Figure 10. Pseudo velocity curve of differences in mean weights between successive groups of males 6-18 years of age, by half-year age group (smoothed by a 3-period moving average) and race.

of the Negro boys than it is below that of the white girls. In addition, it appears that the racial and sex differences in this sitting height/stature ratio are additive: e.g., the white girls' ratio exceeds the Negro boys' ratio by, approximately, the sum of its excess over the ratios of the white boys and the Negro girls.

DISCUSSION

Over the 12-year span, 6-17 years of age, the differences between the two overall dimensions—stature and weight—in the two races are different for the two sexes both in size attained at a given age, as shown in the distance curves (figures 1-4, 9, and 11), and in the pattern or rate of this accrued size, as compared in the pseudo velocity curves.

Although the relatively small sample sizes of the Negro boys and girls, grouped by half-year age intervals, created much statistical noise, precluding a detailed comparison in this report of all four parameters of the growth spurt which were used in the U.S.-British comparisons in the first report, Series 11, Number 124,[1] smoothing the means by the 3-period moving average technique enables sufficient comparison. The comparative distance curves for both height and weight are considered sufficient to gauge all significant points of similarity and difference. The pseudo velocity curves adequately compare the patterns and rates of growth, especially when used in the context of the first report.

By height, the white and Negro boys display a consistent and remarkable similarity over the 12-year span. During the first several years the Negro boys tended to be slightly taller than the white boys by about the same margin that the white boys were taller during the last few years of the 12-year span. But for the largest

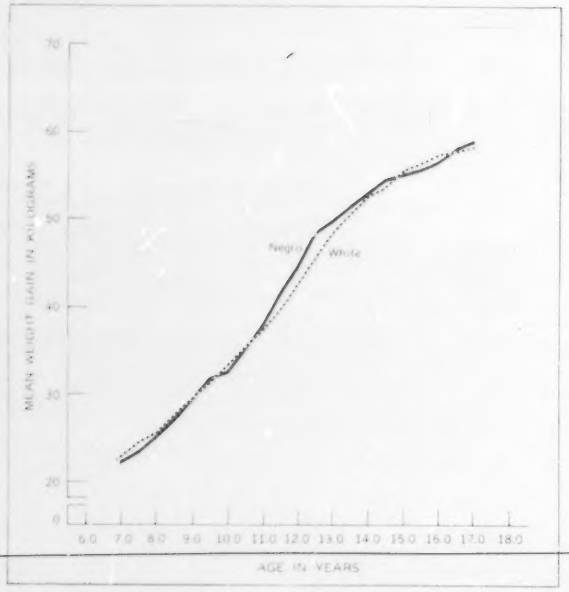

Figure 11. Distance curve of mean weight attained by females 6-18 years of age, by half-year age group (smoothed by a 3-period moving average) and race.

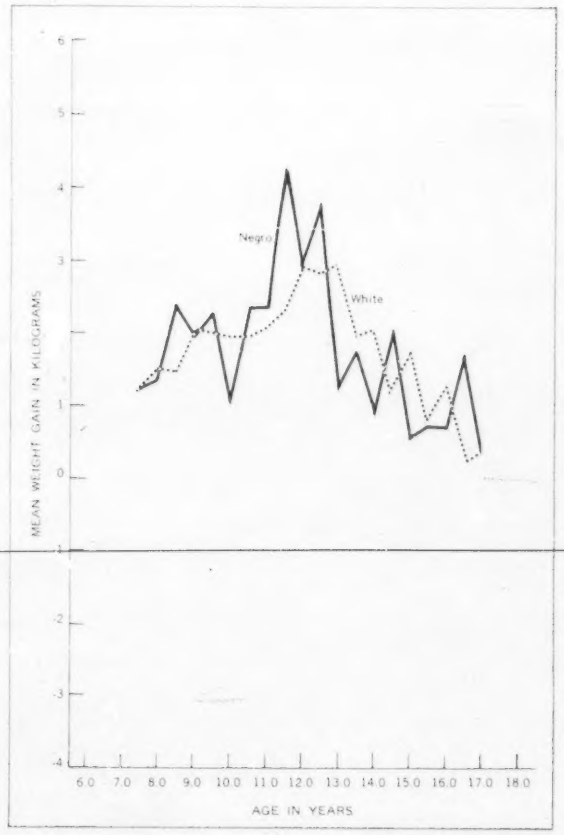

Figure 12. Pseudo velocity curve of differences in mean weights between successive groups of females 6-18 years of age, by half-year age group (smoothed by a 3-period moving average) and race.

part of the age span, there were no consistent differences in attained mean heights between the two groups. Furthermore, the height spurts were identical when comparing timing and relative magnitude of the two peak velocities.

In contrast to the marked similarity in the height curves, the difference in weight was quite striking—in consistency and in magnitude. At no time during the 12-year span were the mean weights of Negro boys greater than the mean weights of their white peers (except erratically, by the noise of small samples). At 13 and 14 years of age they were essentially the same, but during the rest of the age span the mean weights of the white boys were from 1 to 6 kilograms greater than the corresponding means for the Negro boys.

This discrepancy between the height and the weight growth patterns of white and Negro boys is more understandable when the marked disparity between the mean sitting height/stature ratios of the two groups is taken into account. This finding means that, in general, white boys have longer trunks while Negro boys tend to have longer legs. And of course, the trunk, being thicker, weighs more per unit length than do the legs. In other words although white boys and Negro boys have one similar overall dimension, stature, they are assembled somewhat differently. They have arrived at similar statures by reciprocally balancing the disparate lengths of the two major component parts; and this difference in the proportion of parts gives rise to some of the difference in the other overall dimension, weight.

This finding is entirely consistent with the major conclusion of the more detailed examination of many additional body segments, widths, and girths of children 6-11 years in Cycle II, which will be reported in a forthcoming NCHS publication.[14] In these younger

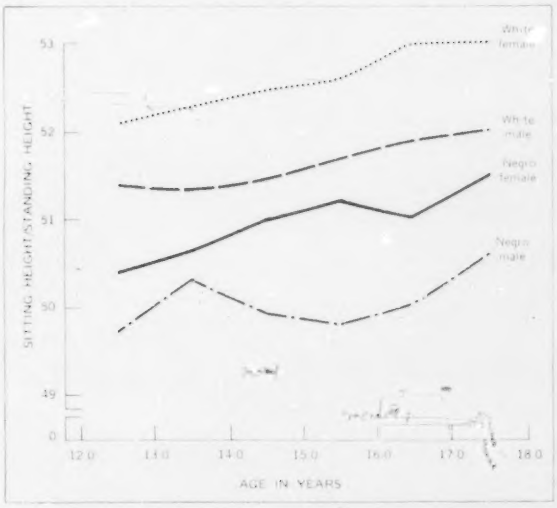

Figure 13. Mean sitting height/standing height ratio for youths 12-17 years of age by sex and race.

children there was a marked and consistent racial difference: white children of both sexes consistently had larger mean lengths and girths of the trunk while Negro children consistently had greater mean lengths of the limbs. (Furthermore, there was an apparent proximal-distal gradient to these limb differences).

In addition, the detailed racial comparisons of subcutaneous fat distributions, as estimated by skinfold measurements, which have already been reported on children aged 6-11 years in *Vital and Health Statistics* Series 11, Number 120[15]—and which will be in another Series 11 report[16] on youths 12-17 years, demonstrate a greater subcutaneous fat thickness in white children over the trunk and the limbs than in their Negro counterparts—the difference being somewhat greater over the limbs.

That most of these differences are primarily of genetic rather than environmental origin would seem incontestable at this time. The forthcoming report analyzing the more detailed measurements of segmental lengths, girths, and widths on youths 12-17 years of age which parallels the report previously cited[14] on children 6-11 years of age will help clarify these findings.

The girls' pattern of differences is quite unlike that of the boys. Whereas the white and Negro boys differed by the relatively more adventitious dimension of weight, the most marked difference between Negro and white girls was in the more fundamental growth characteristic, stature. Moreover, the girls' difference was much more consistent and seems to describe a definite pattern.

In the younger part of the total age span 6 to 18 years the HES data demonstrate that the mean height of Negro girls is greater than that of white girls. This difference is consistently maintained until after age 13½ years when the pseudo growth spurts for both groups of girls have been completed and the velocity of apparent height increment has slowed far below the preadolescent velocity (figures 4 and 8). The Negro girls' height velocity, which peaked both higher and a half year earlier than the white girls', starting at about 12½ years diminishes correspondingly earlier. The white girls, on the average, continue to grow in stature for a half year longer than the Negro girls, which not only eradicates the deficit of the earlier years but also enables the white girls to end up with approximately 0.5 cm. larger smoothed mean heights (table 4).

The pattern of differences in weight seems to more or less mirror this, but the relative magnitude of the difference in weight is less. The biggest difference between the two pseudo growth curves is from 11½ to 13½ years which, probably, only reflects the earlier growth spurt in the Negro girls.

The girls' pattern of racial difference by stature/sitting height ratios was almost identical to that of the boys'.

An additional dimension, important to an understanding of these differences in body growth patterns which have just been discussed, is comparative *biological timing*. The first stage of adding this dimension to this series of reports will be accomplished by the forthcoming reports on "skeletal age" assessment by age, sex, race, and sociodemographic variables covering the ages 6-11 and 12-17 years. Additionally for the adolescent years, 12-17, there will be further analyses by other "biological timers," such as age at menarche and youth's stage of pubertal development which was assessed by the examining physician using Tanner's[17] classification of primary and secondary sex characteristics.

After weighing and considering all the differences in growth patterns by race and sex which have been discussed here, it is expected that almost no difference will be found, either in skeletal age or by other maturational indices, between white and Negro boys from 6 years of age to 18 (including the timing of the adolescent growth spurt which has already been seen in Series 11, Number 124).

Between white and Negro girls, on the other hand, definite differences in biologic timing are expected, solely on the basis of these data and their interrelationships. It is expected that from age 6 to about 13 years, mean skeletal age of Negro girls will be consistently earlier, or more mature, by approximately 3 to 6 months than that of white girls of comparable chronologic age.

These expected differences in biological maturity would adequately explain the greater differences in height and weight between white and Negro girls than between white and Negro boys which have been discussed. At that time when predictions are no longer necessary (i.e., there will be not only *certainty* of the differences in timing, but also quantification of these differences for use in further analyses), a more complex analysis of differences in body composition will extend these present descriptive findings.

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Table 1. Height in centimeters for youths aged 12-17 years by single year of age by race and sex: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Age, race, and sex	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
WHITE			Height in centimeters									
Male												
12 years	540	1,746	152.3	8.40	0.48	138.6	141.2	146.8	152.5	157.4	162.7	165.9
13 years	542	1,728	159.9	9.11	0.49	145.4	148.3	153.5	159.4	166.2	172.6	174.7
14 years	527	1,685	166.9	8.70	0.53	152.2	154.9	161.0	168.2	173.3	177.0	179.7
15 years	525	1,646	171.6	7.23	0.35	158.5	161.8	167.1	172.3	176.1	180.5	183.1
16 years	496	1,594	174.4	6.94	0.37	163.2	165.7	170.3	174.3	178.8	183.4	185.8
17 years	417	1,527	175.7	6.99	0.42	162.8	167.1	171.2	175.9	180.2	184.4	187.3
Female												
12 years	455	1,684	155.0	7.43	0.34	141.5	145.2	150.7	155.2	159.9	164.2	167.2
13 years	490	1,667	158.7	7.02	0.34	146.6	149.4	154.1	158.9	163.4	167.7	170.1
14 years	484	1,632	161.4	6.25	0.35	151.1	153.7	153.7	161.1	165.4	169.5	171.5
15 years	425	1,594	162.4	6.98	0.53	151.3	153.1	157.5	162.6	167.3	170.7	173.0
16 years	441	1,542	162.8	6.41	0.38	151.6	154.4	158.6	163.3	166.6	171.0	173.1
17 years	393	1,501	163.0	6.32	0.32	152.6	155.1	158.3	163.1	167.3	171.2	172.9
NEGRO												
Male												
12 years	101	280	152.1	6.87	0.92	140.6	143.2	146.8	152.6	156.6	161.4	164.1
13 years	80	262	159.7	9.29	1.00	143.5	147.5	153.5	160.9	165.6	173.1	174.4
14 years	88	256	165.7	8.62	0.92	152.0	154.5	158.7	166.1	171.1	177.9	180.0
15 years	84	240	170.4	7.81	0.85	156.7	160.9	165.5	168.9	176.0	179.8	182.7
16 years	57	231	174.0	6.80	1.26	162.1	163.1	170.1	174.5	178.6	181.7	183.0
17 years	69	225	174.5	7.01	0.68	162.4	165.8	169.6	174.2	179.9	183.3	186.8
Female												
12 years	88	271	156.5	6.59	0.51	145.5	148.6	152.6	155.9	161.3	163.8	168.5
13 years	91	275	159.0	6.55	0.66	147.9	150.2	154.6	159.2	164.1	166.6	169.5
14 years	101	265	161.5	5.69	0.66	151.7	153.5	157.4	162.1	166.0	168.6	169.8
15 years	73	235	161.7	6.16	0.71	153.0	154.0	157.4	161.5	165.4	170.1	173.3
16 years	93	242	161.9	6.51	0.90	151.4	153.2	157.6	161.7	166.6	169.9	173.3
17 years	74	236	162.7	6.61	0.50	151.3	152.6	158.3	164.1	168.1	169.9	173.5

NOTE: n = sample size, N = estimated number of youths in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 2. Height in centimeters for whites aged 12-18 years by half-year age group and sex: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Age and sex	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Male			Height in centimeters									
12 years	101	331	150.6	8.87	1.03	138.1	138.7	144.6	150.2	156.4	161.7	165.5
12 1/2 years	291	923	151.7	7.92	0.72	139.2	141.5	146.4	152.3	156.6	161.6	164.1
13 years	279	912	155.4	8.53	0.48	142.0	145.5	149.8	155.5	160.7	166.5	170.1
13 1/2 years	288	903	160.0	8.99	0.73	145.5	148.6	153.5	159.4	165.8	172.8	175.4
14 years	239	792	163.7	8.67	0.74	148.6	152.2	157.6	163.5	170.2	174.3	177.4
14 1/2 years	271	846	166.7	8.87	0.70	151.5	154.6	159.8	168.3	173.3	177.2	179.4
15 years	276	872	169.7	7.80	0.53	156.1	159.3	164.1	170.3	175.3	179.2	181.8
15 1/2 years	275	851	171.6	7.04	0.40	159.2	162.8	167.3	171.9	175.6	180.6	183.5
16 years	255	841	173.5	6.65	0.40	162.1	169.8	169.7	173.8	177.7	181.1	184.2
16 1/2 years	226	720	174.6	6.59	0.38	164.2	166.4	170.9	174.7	178.7	183.2	185.2
17 years	232	792	175.5	7.08	0.55	163.3	166.4	170.6	176.1	180.0	184.2	186.6
17 1/2 years	209	754	175.8	6.94	0.65	163.3	162.4	170.9	175.9	179.8	184.8	188.0
18 years	105	387	175.4	7.21	0.81	162.4	166.1	170.7	175.4	180.4	185.3	186.6
Female												
12 years	75	272	153.0	6.51	0.88	140.8	145.3	149.5	152.8	156.2	159.4	167.2
12 1/2 years	254	947	155.2	7.73	0.52	141.2	143.8	150.7	155.7	160.5	164.5	166.7
13 years	265	935	156.8	7.12	0.41	144.5	147.0	152.1	156.9	161.5	166.4	167.9
13 1/2 years	231	793	159.0	6.91	0.49	147.4	149.8	154.4	158.7	163.6	168.2	170.2
14 years	249	844	160.2	6.40	0.49	149.3	151.8	156.5	160.7	164.5	167.8	170.1
14 1/2 years	234	770	161.4	6.35	0.43	150.4	153.5	157.3	161.2	165.3	170.1	171.3
15 years	221	778	162.0	6.25	0.43	152.3	154.5	157.4	161.6	166.8	169.6	171.8
15 1/2 years	215	834	162.9	7.49	0.68	151.6	153.3	157.8	162.8	168.2	171.8	173.8
16 years	238	854	162.3	6.58	0.53	150.8	153.5	157.7	162.5	166.8	170.1	172.5
16 1/2 years	188	649	162.7	6.39	0.38	151.7	154.4	158.5	163.3	166.5	170.9	172.8
17 years	235	878	163.1	6.43	0.50	151.6	155.0	158.8	163.7	166.8	171.5	173.5
17 1/2 years	183	675	162.8	5.88	0.47	152.8	155.4	158.4	162.9	166.8	170.7	171.9
18 years	100	389	162.9	6.90	0.68	152.6	154.5	157.5	162.2	167.7	171.6	175.5

NOTE: n=sample size; N=estimated number of youths in population in thousands; $\bar{X}$=mean; s=standard deviation; $s_{\bar{x}}$=standard error of the mean.

Table 3. Height in centimeters for Negroes aged 12-18 years by half-year age group and sex: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Age and sex	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Male			Height in centimeters									
12 years	19	58	150.7	6.20	2.37	141.3	142.8	146.2	150.3	153.9	159.8	161.8
12 1/2 years	52	135	150.4	6.85	0.82	138.8	140.9	144.8	151.0	155.4	158.7	163.1
13 years	53	160	156.2	9.14	1.26	138.5	144.2	150.5	156.5	163.4	167.4	170.6
13 1/2 years	38	129	160.5	8.25	1.40	150.0	150.6	154.3	158.4	167.1	174.1	174.6
14 years	35	106	162.5	8.56	1.97	150.4	151.4	153.7	163.8	167.5	174.8	178.4
14 1/2 years	51	153	166.3	8.17	1.38	154.6	157.2	158.9	167.1	171.0	177.2	183.1
15 years	40	111	168.0	8.85	1.39	155.2	156.4	163.0	168.1	173.4	179.4	190.0
15 1/2 years	45	132	169.6	6.81	0.98	159.5	160.6	165.8	168.5	174.3	178.7	181.8
16 years	38	139	171.8	7.64	1.77	157.4	162.1	166.4	174.2	178.3	180.2	181.6
16 1/2 years	23	86	175.6	4.59	0.69	168.1	170.3	172.3	175.3	178.8	181.4	182.8
17 years	28	102	173.8	6.82	1.23	163.2	165.3	169.2	173.6	177.6	182.6	183.6
17 1/2 years	32	100	174.5	8.17	1.67	161.7	162.7	169.1	173.4	180.6	186.2	188.8
18 years	25	82	175.9	5.72	1.21	168.2	170.2	173.0	175.9	180.2	181.4	185.6
Female												
12 years	26	76	156.8	6.56	1.20	145.6	149.0	153.1	150.0	159.8	167.7	170.0
12 1/2 years	40	130	155.2	6.30	1.10	145.4	147.8	152.1	155.1	159.8	162.6	163.9
13 years	46	135	158.6	6.69	0.51	149.2	150.1	153.8	158.8	163.2	168.4	169.7
13 1/2 years	58	178	159.8	6.23	0.92	150.2	151.2	156.3	160.5	164.4	166.2	169.6
14 years	38	101	159.3	6.55	1.27	148.1	148.7	154.5	159.6	165.1	168.3	169.1
14 1/2 years	51	132	161.5	5.75	0.85	151.8	154.0	157.3	161.5	165.7	168.6	171.2
15 years	41	124	161.7	6.39	0.94	150.6	153.4	157.5	162.3	165.4	170.2	173.4
15 1/2 years	34	105	161.3	5.95	0.69	153.3	154.3	156.8	161.1	166.3	168.8	172.2
16 years	45	135	162.3	5.39	0.76	153.4	155.4	158.7	163.1	166.1	170.1	170.6
16 1/2 years	47	123	161.6	6.44	1.10	151.4	152.6	157.2	162.0	166.5	169.6	172.3
17 years	40	108	163.5	6.37	1.26	154.1	155.0	159.2	163.1	168.2	174.0	174.6
17 1/2 years	39	126	162.0	7.42	0.76	150.4	151.4	155.9	162.6	168.1	172.1	174.0
18 years	15	49	163.2	5.31	2.00	152.7	153.7	158.7	163.8	167.6	169.1	169.2

NOTE: n = sample size; N = estimated number of youths in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 4. Height in centimeters for whites aged 6-18 years by half-year age group and sex: differences between successive groups, 3-period moving averages of mean heights, and differences between successive moving averages, United States, 1966-70

Age	Male				Female			
	$\bar{X}$	d^1	3-period moving average	d^2	$\bar{X}$	d^1	3-period moving average	d^2
6 years	(1)				(1)			
		3.1				3.3		
6 1/2 years	118.3				117.4			
		3.0	121.4			2.9	120.6	
7 years	121.4			3.0	120.7			2.9
		3.1				2.5		
7 1/2 years	124.4		124.4	2.8	123.6		123.5	2.8
		2.3				3.1		
8 years	127.5		127.2	2.8	126.1		126.3	2.9
		2.9				3.0		
8 1/2 years	129.8		130.0	2.7	129.2		129.2	2.9
		2.8				2.8		
9 years	132.7		132.7	2.6	132.2		132.1	3.1
		2.1				3.5		
9 1/2 years	135.5		135.3	2.4	135.0		135.2	2.8
		2.4				2.1		
10 years	137.6		137.7	2.6	138.5		138.0	3.0
		3.2				3.2		
10 1/2 years	140.0		140.3	2.8	140.6		141.0	3.0
		3.0				3.7		
11 years	143.2		143.1	2.9	143.8		144.0	3.3
		2.3				3.0		
11 1/2 years	146.2		146.0	2.8	147.5		147.3	3.8
		3.2				4.7		
12 years	148.5		148.8	3.1	150.5		151.1	3.1
		3.7				1.6		
12 1/2 years	151.7		151.9	3.8	155.2		154.2	2.8
		4.6				2.2		
13 years	155.4		155.7	4.0	156.8		157.0	1.7
		3.7				1.2		
13 1/2 years	160.0		159.7	3.8	159.0		158.7	1.5
		3.0				1.2		
14 years	163.7		163.5	3.2	160.2		160.2	1.0
		3.0				0.6		
14 1/2 years	166.7		166.7	2.6	161.4		161.2	0.9
		1.9				0.9		
15 years	169.7		169.3	2.3	162.0		162.1	0.3
		1.9				-0.6		
15 1/2 years	171.6		171.6	1.6	162.9		162.4	0.2
		1.1				0.4		
16 years	173.5		173.2	1.3	162.3		162.6	0.1
		0.9				0.4		
16 1/2 years	174.6		174.5	0.8	162.7		162.7	0.2
		0.3				-0.3		
17 years	175.5		175.3		163.1		162.9	
17 1/2 years	175.8				162.8			
18 years	(1)				(1)			

[1] No value is recorded for this age group since the average age of youths falling in this category was not sufficiently close to the age specified.

NOTE: $\bar{X}$ = mean, d^1 = difference between successive group means, and d^2 = difference between successive moving averages.

Table 5. Height in centimeters for Negroes aged 6-18 years by half-year age group and sex: differences between successive groups, 3-period moving averages of mean heights, and differences between successive moving averages, United States, 1966-70

Age	Male				Female			
	$\bar{X}$	d^1	3-period moving average	d^2	$\bar{X}$	d^1	3-period moving average	d^2
6 years	(1)				(1)			
		4.5				2.7		
6 1/2 years	118.4				119.1			
		2.0	122.1			2.9	121.9	
7 years	122.9			3.8	121.8			2.7
		5.1				2.7		
7 1/2 years	124.9		125.9		124.7		124.6	
		1.0		2.7		1.2		2.3
8 years	130.0		128.6		127.4		126.9	
		1.3		2.5		6.6		3.5
8 1/2 years	131.0		131.1		128.6		130.4	
		1.9		1.4		2.4		3.4
9 years	132.3		132.5		135.2		133.8	
		2.3		1.8		1.5		3.5
9 1/2 years	134.2		134.3		137.6		137.3	
		4.2		2.8		1.5		1.8
10 years	136.5		137.1		139.1		139.1	
		1.1		2.6		5.5		2.8
10 1/2 years	140.7		139.7		140.6		141.9	
		3.7		3.0		3.0		3.4
11 years	141.8		142.7		146.1		145.3	
		5.0		3.2		5.3		4.6
11 1/2 years	145.5		145.9		149.1		149.9	
		-0.1		2.9		0.8		3.0
12 years	150.5		148.8		154.4		152.9	
		5.8		3.6		3.4		3.2
12 1/2 years	150.4		152.4		155.2		156.1	
		4.3		3.3		1.2		1.8
13 years	156.2		155.7		158.6		157.9	
		2.0		4.0		-0.5		1.3
13 1/2 years	160.5		159.7		159.8		152.9	
		3.8		3.4		2.2		1.0
14 years	162.5		163.1		159.3		160.2	
		1.7		2.5		0.2		0.6
14 1/2 years	166.3		165.6		161.5		160.8	
		1.6		2.4		-0.4		0.7
15 years	168.0		168.0		161.7		161.5	
		2.2		1.8		1.0		0.3
15 1/2 years	169.6		169.8		161.3		161.8	
		3.8		2.5		-0.7		-0.1
16 years	171.8		172.3		162.3		161.7	
		-1.8		1.4		1.9		0.8
16 1/2 years	175.6		173.7		161.6		162.5	
		0.7		0.9		-1.5		-0.1
17 years	173.8		174.6		163.5		162.4	
17 1/2 years	174.5				162.0			
18 years	(1)				(1)			

[1] No value is recorded for this age group since the average age of youths falling in this category was not sufficiently close to the age specified.

NOTE: $\bar{X}$=mean, d^1=difference between successive group means, and d^2=difference between successive moving averages.

Table 6. Weight in kilograms for youths aged 12-17 years by single year of age by race and sex: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Age, race, and sex	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
			Weight in kilograms									
WHITE												
Male												
12 years	540	1,746	43.09	9.273	0.385	30.46	32.43	36.46	41.98	48.16	56.54	60.36
13 years	542	1,728	49.91	11.600	0.549	35.29	36.88	41.15	48.27	56.37	64.42	70.57
14 years	527	1,685	56.99	12.373	0.635	39.27	41.99	49.01	55.63	63.54	72.26	78.79
15 years	525	1,646	62.26	11.321	0.444	46.67	49.29	54.83	61.19	67.63	76.64	84.44
16 years	496	1,594	65.01	11.484	0.572	49.78	52.24	57.92	63.40	70.41	79.03	84.93
17 years	417	1,527	65.22	11.524	0.389	52.46	55.32	60.67	66.45	74.12	81.98	91.49
Female												
12 years	455	1,684	46.18	9.734	0.460	32.56	34.82	39.17	45.13	51.59	58.55	62.83
13 years	490	1,667	50.50	9.888	0.521	36.71	38.99	43.47	49.03	56.65	62.90	67.31
14 years	484	1,632	54.05	10.322	0.480	40.65	43.18	47.36	52.30	59.07	66.32	71.42
15 years	425	1,594	56.73	11.387	0.528	42.26	44.74	49.13	55.03	61.08	71.35	79.68
16 years	441	1,542	58.01	11.248	0.672	44.88	46.77	51.00	55.79	62.20	70.57	78.96
17 years	393	1,501	57.40	10.279	0.622	44.76	47.01	50.72	55.64	61.68	69.29	75.93
NEGRO												
Male												
12 years	101	280	42.01	8.899	1.273	31.80	33.34	36.80	39.81	45.63	52.45	55.80
13 years	80	262	50.56	12.852	1.441	32.84	35.69	42.45	48.64	59.27	67.46	75.12
14 years	88	256	54.72	12.208	1.577	38.86	40.70	45.61	52.86	61.88	70.00	73.67
15 years	84	240	57.04	10.309	1.237	42.57	46.16	49.83	56.27	62.57	71.21	73.44
16 years	57	231	63.71	11.437	1.634	48.05	48.77	56.68	62.91	68.60	75.86	85.07
17 years	69	225	66.65	11.352	1.564	52.95	57.03	59.98	63.70	71.31	79.81	89.56
Female												
12 years	88	271	49.16	11.065	1.325	34.01	35.70	41.82	46.00	57.26	63.97	68.62
13 years	91	275	50.25	12.582	0.947	36.44	37.79	42.36	47.34	55.40	66.02	81.20
14 years	101	265	55.02	10.304	0.943	39.60	43.84	47.79	53.36	60.80	68.37	72.43
15 years	73	235	55.60	10.422	1.299	41.94	44.30	48.29	53.84	59.55	71.15	75.96
16 years	93	242	58.46	13.100	2.476	44.04	45.29	50.02	55.07	62.21	77.55	86.50
17 years	74	236	58.85	12.141	2.017	43.51	44	48.98	58.49	65.47	71.87	79.92

NOTE: n=sample size; N=estimated number of youths in population in thousands; $\bar{X}$=mean; s = standard deviation; $s_{\bar{x}}$=standard error of the mean.

Table 7. Weight in kilograms for whites aged 12-18 years by half-year age group and sex: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Age and sex	n	N	$\bar{X}$	s	$s_{\bar{X}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Male			Weight in kilograms									
12 years	101	331	41.49	9.844	1.019	28.07	30.29	35.51	39.75	45.41	55.64	59.93
12 1/2 years	291	923	42.57	9.111	0.647	31.03	32.74	35.83	40.93	47.38	56.11	58.93
13 years	279	912	45.59	9.379	0.504	31.41	34.68	39.10	44.66	50.81	59.04	62.13
13 1/2 years	288	903	50.03	11.401	0.943	36.07	36.99	40.90	48.29	56.55	65.81	70.18
14 years	239	792	53.84	11.939	0.711	39.00	40.72	45.54	51.83	59.98	68.86	76.72
14 1/2 years	271	846	56.92	13.002	0.847	38.69	40.80	49.68	55.65	62.23	70.83	80.05
15 years	276	872	60.16	10.982	0.787	44.38	46.90	51.55	59.48	67.03	74.53	76.87
15 1/2 years	275	851	62.31	11.044	0.758	47.91	50.38	55.22	60.43	66.96	77.62	84.86
16 years	255	841	63.95	12.181	1.105	46.82	51.56	56.91	62.27	68.61	78.14	86.03
16 1/2 years	226	720	64.51	10.330	0.631	50.14	52.69	57.21	63.12	70.16	78.46	83.10
17 years	232	792	66.67	11.797	0.589	50.42	53.09	59.17	64.78	73.51	80.52	85.90
17 1/2 years	209	754	68.81	11.303	1.078	52.70	56.34	61.28	67.06	74.56	85.68	91.09
18 years	105	387	68.97	12.283	0.865	53.30	55.59	59.83	67.79	75.00	79.93	98.40
Female												
12 years	75	272	44.17	9.100	1.318	32.38	33.79	37.24	42.87	49.22	58.04	62.08
12 1/2 years	254	947	46.29	9.771	0.775	31.97	34.88	39.16	45.41	52.19	58.74	63.32
13 years	265	935	48.27	9.769	0.586	35.01	37.10	41.52	47.03	53.17	60.93	66.34
13 1/2 years	231	793	50.87	10.355	0.764	36.20	38.58	44.12	49.74	56.62	63.08	68.89
14 years	249	844	52.14	9.356	0.621	38.66	40.47	46.22	51.10	57.43	63.58	67.37
14 1/2 years	234	770	54.41	11.699	0.501	41.18	43.11	46.86	52.05	59.53	68.79	72.30
15 years	221	778	54.53	9.153	0.795	41.16	43.96	47.96	54.13	59.73	65.20	69.54
15 1/2 years	215	834	57.46	12.161	0.934	41.64	44.87	49.38	55.65	61.21	72.64	82.88
16 years	238	854	56.76	9.968	0.404	44.33	46.47	50.75	54.58	60.71	69.28	77.71
16 1/2 years	188	649	58.16	11.688	1.200	45.88	46.75	50.65	55.61	62.86	69.84	78.11
17 years	235	878	58.17	11.682	0.813	44.34	47.09	50.43	56.69	61.94	72.02	76.65
17 1/2 years	183	675	57.87	9.948	0.837	45.61	47.41	51.10	55.31	63.15	70.12	77.72
18 years	100	389	56.95	9.929	0.881	44.38	46.44	50.58	55.42	61.31	69.06	75.19

NOTE: n = sample size; N = estimated number of youths in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{X}}$ = standard error of the mean.

Table 8. Weight in kilograms for Negroes aged 12-18 years by half-year age group and sex: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Age and sex	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
Male			Weight in kilograms									
12 years-----	19	58	41.63	7.768	3.350	31.29	31.95	36.24	38.45	46.64	52.92	54.89
12 1/2 years-	52	135	40.68	7.537	1.103	31.29	32.71	36.69	39.61	44.05	50.08	53.16
13 years-----	53	160	45.06	11.688	1.702	31.06	33.48	36.75	42.21	50.83	61.23	66.24
13 1/2 years-	38	129	52.63	12.669	2.551	36.52	38.61	43.11	49.09	61.69	67.74	75.55
14 years-----	35	106	51.96	15.047	3.001	36.93	37.86	42.73	49.29	57.18	68.05	88.32
14 1/2 years-	51	153	57.01	10.624	2.081	41.55	44.60	47.31	54.75	66.07	72.53	75.17
15 years-----	40	111	53.23	11.255	1.909	42.02	42.47	46.25	51.54	56.79	65.34	73.09
15 1/2 years-	45	132	55.98	8.686	1.481	40.77	43.59	49.93	56.19	61.69	68.03	73.24
16 years-----	38	139	61.13	12.950	2.210	46.39	48.41	51.64	60.24	68.41	71.91	86.08
16 1/2 years-	23	86	63.41	8.148	1.567	51.14	53.27	58.23	61.64	69.25	75.68	78.78
17 years-----	28	102	65.02	10.516	1.901	46.32	50.26	59.66	64.82	68.81	84.16	85.49
17 1/2 years-	32	100	61.98	12.652	3.100	54.35	57.42	61.05	63.61	72.27	79.97	90.61
18 years-----	25	82	67.73	8.579	1.515	57.50	57.85	61.30	66.29	71.66	82.39	86.69
Female												
12 years-----	26	76	48.41	10.096	2.302	35.55	36.97	41.59	44.46	57.21	62.57	66.91
12 1/2 years-	40	130	47.26	10.898	1.862	30.96	33.72	38.73	45.62	55.27	62.59	66.74
13 years-----	46	135	51.48	12.846	2.013	34.64	37.30	42.80	48.46	62.22	67.37	69.63
13 1/2 years-	58	178	50.32	12.257	1.841	36.65	38.84	43.03	48.85	55.28	61.84	81.82
14 years-----	38	101	52.49	11.830	1.866	35.37	37.33	45.68	50.92	59.02	68.39	75.25
14 1/2 years-	51	132	54.40	9.045	1.397	40.06	43.97	47.37	53.54	60.62	67.85	68.82
15 years-----	41	124	56.85	10.918	2.103	42.63	47.08	49.12	53.84	60.53	71.30	84.17
15 1/2 years-	34	105	54.11	10.412	1.346	39.49	43.55	46.69	51.89	58.97	67.97	75.73
16 years-----	45	135	56.63	8.553	1.192	45.30	46.26	50.92	56.14	59.86	66.57	73.67
16 1/2 years-	47	123	58.94	13.746	3.742	43.39	44.86	49.70	54.41	64.21	84.51	86.69
17 years-----	40	108	55.27	13.226	2.895	45.18	46.66	48.79	58.26	63.91	74.63	79.98
17 1/2 years-	39	126	57.81	12.148	1.899	40.04	43.79	49.22	58.20	65.01	68.33	82.65
18 years-----	15	49	63.26	13.279	3.286	44.84	47.12	54.91	61.12	71.35	73.42	100.26

NOTE: n = sample size; N = estimated number of youths in population in thousands; $\bar{X}$ = mean; s = standard deviation; $s_{\bar{x}}$ = standard error of the mean.

Table 9. Weight in kilograms for whites aged 6-18 years by half-year age group and sex: differences between successive groups, 3-period moving averages of mean weights, and differences between successive moving averages, United States, 1966-70

Age	Male				Female			
	$\bar{X}$	d^1	3-period moving average	d^2	$\bar{X}$	d^1	3-period moving average	d^2
6 years	(1)				(1)			
6 1/2 years	21.83	1.57			21.48	1.43		
7 years	23.40	1.31	23.31	1.53	22.91	1.67	22.99	1.31
7 1/2 years	24.71	1.70	24.84	1.52	24.58	0.84	24.30	1.56
8 years	26.41	1.56	26.36	1.50	25.42	2.15	25.86	1.54
8 1/2 years	27.97	1.23	27.86	1.68	27.57	1.65	27.40	2.05
9 years	29.20	2.24	29.54	1.48	29.22	2.33	29.45	2.01
9 1/2 years	31.44	0.98	31.02	1.57	31.55	2.07	31.46	1.96
10 years	32.42	1.48	32.59	1.61	33.62	1.46	33.42	1.96
10 1/2 years	33.90	2.37	34.20	2.02	35.08	2.37	35.38	2.06
11 years	36.27	2.22	36.22	2.31	37.45	2.35	37.44	2.33
11 1/2 years	38.49	2.34	38.53	2.10	39.80	2.25	39.77	2.94
12 years	40.83	1.74	40.63	2.37	42.05	4.24	42.71	2.83
12 1/2 years	42.57	3.02	43.00	3.07	46.29	1.98	45.54	2.94
13 years	45.59	4.44	46.06	3.76	48.27	2.60	48.48	1.95
13 1/2 years	50.03	3.81	49.82	3.78	50.87	1.27	50.43	2.04
14 years	53.84	3.08	53.60	3.38	52.14	2.27	52.47	1.22
14 1/2 years	56.92	3.24	56.97	2.82	54.41	0.12	53.69	1.78
15 years	60.16	2.15	59.80	2.34	54.53	2.93	55.47	0.78
15 1/2 years	62.31	1.64	62.14	1.45	57.46	-0.70	56.25	1.21
16 years	63.95	0.56	63.59	1.45	56.76	1.40	57.46	0.24
16 1/2 years	64.51	2.16	65.04	1.62	58.16	0.01	57.70	0.37
17 years	66.67	2.14	66.66		58.17	-0.30	58.07	
17 1/2 years	68.81				57.87			
18 years	(1)				(1)			

[1]No value is recorded for this age group since the average age of youths falling in this category was not sufficiently close to the age specified.

NOTE: $\bar{X}$=mean, d^1=difference between successive group means, and d^2=difference between successive moving averages.

Table 10. Weight in kilograms for Negroes aged 6-18 years by half-year age group and sex: differences between successive groups, 3-period moving averages of mean weights, and differences between successive moving averages, United States, 1966-70

Age	Male				Female			
	$\bar{X}$	d^1	3-period moving average	d^2	$\bar{X}$	d^1	3-period moving average	d^2
6 years	(1)				(1)			
6 1/2 years	21.37				21.54			
		1.81				0.66		
7 years	23.18		22.88		22.20		22.51	
		0.91		1.57		1.58		1.26
7 1/2 years	24.09		24.45		23.78		23.77	
		1.99		1.46		1.56		1.38
8 years	26.08		25.91		25.34		25.15	
		1.47		1.16		0.99		2.36
8 1/2 years	27.55		27.07		26.33		27.51	
		0.03		0.83		4.53		1.95
9 years	27.58		27.90		30.86		29.46	
		0.99		1.39		0.34		2.24
9 1/2 years	28.57		29.29		31.20		31.70	
		3.14		1.54		1.83		1.12
10 years	31.71		30.83		33.03		32.82	
		0.51		2.15		1.20		2.38
10 1/2 years	32.22		32.98		34.23		35.20	
		2.80		1.54		4.11		2.38
11 years	35.02		34.52		38.34		37.58	
		1.29		2.75		1.83		4.28
11 1/2 years	36.31		37.27		40.17		41.86	
		4.18		1.89		6.91		2.98
12 years	40.49		39.16		47.08		44.84	
		0.19		2.92		0.18		3.77
12 1/2 years	40.68		42.08		47.26		48.61	
		4.38		4.04		4.22		1.24
13 years	45.06		46.12		51.48		49.85	
		7.57		3.76		-0.66		1.75
13 1/2 years	52.63		49.88		50.82		51.60	
		-0.67		3.99		1.67		0.97
14 years	51.96		53.87		52.49		52.57	
		5.05		0.20		1.91		2.01
14 1/2 years	57.01		54.07		54.40		54.58	
		-3.78		1.34		2.45		0.54
15 years	53.23		55.41		56.85		55.12	
		2.75		1.37		-2.74		0.74
15 1/2 years	55.98		56.78		54.11		55.86	
		5.15		3.39		2.54		0.70
16 years	61.13		60.17		56.63		56.56	
		2.28		3.02		2.31		1.72
16 1/2 years	63.41		63.19		58.94		58.28	
		1.61		2.28		0.33		0.39
17 years	65.02		65.47		59.27		58.67	
		2.96				-1.46		
17 1/2 years	67.98				57.81			
18 years	(1)				(1)			

[1]No value is recorded for this age group since the average age of youths falling in this category was not sufficiently close to the age specified.

NOTE: $\bar{X}$=mean, d^1=difference between successive group means, and d^2=difference between successive moving averages.

Table 11. Sitting height of youths aged 12-17 years by sex, race, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Age, race, and sex	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
WHITE			Height in centimeters									
Male												
12 years	540	1,747	78.3	4.10	0.24	72.0	73.0	75.5	78.2	80.8	83.6	85.3
13 years	542	1,729	81.9	4.87	0.29	74.4	75.8	78.4	81.6	85.1	89.0	90.5
14 years	527	1,686	85.7	4.89	0.31	77.7	78.8	82.3	86.2	89.3	91.7	93.3
15 years	525	1,646	88.7	3.93	0.23	81.5	83.6	86.0	88.9	91.5	93.6	95.1
16 years	496	1,594	90.4	3.90	0.14	83.5	85.7	88.2	90.6	93.1	95.2	96.5
17 years	417	1,528	91.4	3.51	0.20	84.9	86.7	89.3	91.6	93.7	95.7	97.0
Female												
12 years	455	1,685	80.7	3.86	0.17	74.0	75.5	78.2	81.0	83.2	85.7	87.1
13 years	490	1,667	83.0	3.67	0.17	76.7	77.9	80.8	83.3	85.7	87.5	88.7
14 years	484	1,633	84.7	3.29	0.18	79.5	80.7	82.7	84.7	86.8	88.7	90.0
15 years	425	1,594	85.4	3.49	0.24	79.3	81.2	82.9	85.7	87.7	89.7	90.9
16 years	441	1,542	86.2	3.08	0.18	81.3	82.3	84.1	86.2	87.9	90.2	91.1
17 years	393	1,502	86.4	3.05	0.16	81.1	82.3	84.3	86.5	88.5	90.3	90.9
NEGRO												
Male												
12 years	101	280	75.6	3.61	0.45	69.6	71.3	73.2	75.5	77.9	79.9	81.0
13 years	80	262	80.3	4.78	0.58	72.5	74.3	76.7	80.4	83.8	86.5	86.9
14 years	88	256	82.6	5.11	0.58	75.2	76.3	78.2	82.6	85.6	90.2	91.6
15 years	84	241	84.9	4.56	0.56	77.4	79.1	81.7	84.9	88.2	90.5	92.6
16 years	57	231	86.9	4.52	0.87	79.3	81.1	83.7	87.7	89.7	91.8	93.7
17 years	69	225	88.3	3.94	0.41	82.3	83.5	84.9	88.7	91.1	92.9	93.7
Female												
12 years	88	272	79.0	3.97	0.41	74.0	74.4	76.4	78.7	82.0	84.7	85.7
13 years	91	275	80.4	3.46	0.30	75.2	76.1	78.3	80.0	82.6	85.3	86.2
14 years	101	266	82.3	3.48	0.53	76.8	77.6	79.7	82.4	85.2	86.7	88.5
15 years	73	235	82.7	3.00	0.22	78.0	78.6	80.9	82.5	84.4	86.5	88.4
16 years	93	243	82.6	3.80	0.54	76.3	77.3	79.8	82.8	85.4	87.0	88.8
17 years	74	237	83.7	3.20	0.34	78.4	79.4	81.0	84.2	86.4	87.6	88.3

NOTE: n=sample size; N=estimated number of youths in population in thousands; $\bar{X}$=mean; s=standard deviation; $s_{\bar{x}}$=standard error of the mean.

Table 12. Sitting height/standing height ratio of youths aged 12-17 years by sex, race, and age at last birthday: sample size, estimated population size, mean, standard deviation, standard error of the mean, and selected percentiles, United States, 1966-70

Age, race, and sex	n	N	$\bar{X}$	s	$s_{\bar{x}}$	Percentile						
						5th	10th	25th	50th	75th	90th	95th
WHITE			Ratio: (Sitting height/standing height) x 100									
Male												
12 years	540	1,747	51.4	1.17	0.05	49.5	50.0	50.6	51.4	52.1	52.9	53.3
13 years	542	1,729	51.3	1.16	0.06	49.4	49.7	50.5	51.3	52.1	52.7	53.1
14 years	527	1,686	51.4	1.24	0.05	49.4	49.8	50.6	51.3	52.2	53.0	53.6
15 years	525	1,646	51.7	1.30	0.08	49.5	50.0	50.9	51.6	52.6	53.3	53.9
16 years	496	1,594	51.9	1.31	0.06	49.6	50.2	51.0	51.9	52.7	53.5	53.9
17 years	417	1,528	52.0	1.25	0.09	50.0	50.4	51.2	52.0	52.9	53.7	54.0
Female												
12 years	455	1,685	52.1	1.28	0.06	50.0	50.5	51.2	52.1	52.9	53.7	54.2
13 years	490	1,667	52.3	1.31	0.07	50.1	50.6	51.5	52.4	53.1	54.1	54.6
14 years	484	1,633	52.5	1.27	0.08	50.4	50.9	51.7	52.5	53.3	54.1	54.6
15 years	425	1,594	52.6	1.33	0.09	50.4	50.9	51.8	52.7	53.5	54.3	54.8
16 years	441	1,542	53.0	1.32	0.08	50.9	51.4	52.1	52.9	53.8	54.7	55.3
17 years	393	1,502	53.0	1.27	0.08	51.1	51.5	52.3	53.0	53.9	54.6	55.1
NEGRO												
Male												
12 years	101	280	49.7	1.41	0.12	47.4	48.2	48.9	49.7	50.6	51.3	52.0
13 years	80	262	50.3	2.01	0.21	48.3	48.7	49.6	50.0	50.8	52.1	52.4
14 years	88	256	49.9	1.39	0.13	47.7	48.2	48.8	49.8	50.8	51.3	51.8
15 years	84	241	49.8	1.28	0.16	47.6	48.2	49.0	49.8	50.6	51.3	51.8
16 years	57	231	50.0	1.51	0.23	47.7	48.1	48.7	50.1	51.1	52.0	52.6
17 years	69	225	50.6	1.46	0.23	47.8	49.0	49.9	50.7	51.6	52.3	52.7
Female												
12 years	88	272	50.4	1.44	0.16	48.1	48.4	49.4	50.5	51.5	52.2	52.5
13 years	91	275	50.6	1.28	0.12	48.5	49.1	49.6	50.5	51.6	52.1	52.6
14 years	101	266	51.0	1.65	0.20	48.2	49.3	50.0	51.0	52.1	52.8	53.1
15 years	73	235	51.2	1.52	0.15	48.6	48.9	49.9	51.2	52.1	53.5	53.9
16 years	93	243	51.0	1.38	0.16	49.0	49.4	50.2	50.9	51.8	52.8	53.5
17 years	74	237	51.5	1.37	0.21	48.7	49.4	50.7	51.6	52.4	53.2	54.1

NOTE: n=sample size; N=estimated number of youths in population in thousands; $\bar{X}$=mean; s=standard deviation; $s_{\bar{x}}$=standard error of the mean.

APPENDIX

STATISTICAL NOTES

The Survey Design

The sampling plan of the third cycle of the Health Examination Survey followed a multistage, stratified probability sample of clusters of households in land-based segments in which a sample of the U.S. population (including Alaska and Hawaii) aged 12 through 17 years was selected. Excluded were those youths confined to institutions or residing upon any of the reservation lands set aside for use by American Indians.

The sample design of Cycle III is similar to that of Cycle II in that it utilizes the same 40 sample areas and the same segments. The decision to incorporate this feature into Cycle III was not made prior to the selection of the second cycle sample although it is consistent with the early concept of a single program for 6-17 year olds. The final decision to utilize this identical sampling frame was made during the operation of the second cycle program.

The successive elements for this sample design are primary sampling unit, census enumeration district, segment (a cluster of households), household, all eligible youths, and finally, sample youth. Every eligible youth within the defined population has a known and approximately equal chance for selection into the sample.

The steps of drawing the sample were carried out jointly with the Bureau of the Census; the starting points were the 1960 decennial census lists of addresses and the nearly 1,900 primary sampling units (PSU's) into which the entire United States was divided. Each PSU is a standard metropolitan statistical area (SMSA), a county, or a group of two or three contiguous counties. These PSU's were grouped into 40 strata so that each stratum had an average size of about 4.5 million persons. This grouping was done in a manner which maximized the degree of homogeneity within strata with regard to the population size of the PSU's degree of urbanization, geographic proximity, and degree of industrialization. The 40 strata were then classified into four broad geographic regions of 10 strata each and then within each region, cross-classified by four population density classes and by the rates of population change from 1950 to 1960. Using a modified Goodman-Kish controlled-selection technique, one PSU was drawn from each of the 40 strata.

The sampling within PSU's was carried out in several steps. The first was the selection of census enumeration districts (ED's). These ED's are small well-defined areas of about 250 housing units into which the entire Nation was divided for the 1960 population census. Each ED was assigned a "measure of size" equal to the rounded whole number resulting from a "division by nine" of the number of children aged 5-9 in the ED at the time of the 1960 census. A sample of 20 ED's in the sample PSU was selected according to a systematic sampling technique with each ED having a probability of selection proportional to the population of children 5-9 years at the time of the 1960 census date. From each ED a random selection of one measure of size (segment) was taken.

Minor changes required in the Cycle III design were that it be supplemented for new construction to a greater extent than had been necessary in Cycle II and that reserve segments be added. Although it was the plan for Cycle III to use the Cycle II segments, it was recognized that within several PSU's, additional reserve segments would be needed to avoid the risk of having an insufficient number of examinees. This was prompted by the fact that four of the

PSU's in Cycle II had yields of less than 165 eligible children and several others were marginal in their yield. In addition, there was a 3-year interval between Cycle II and Cycle III, so it was quite possible for some segments to have been completely demolished to make room for highway construction or urban redevelopment.

The time available for examinations at a particular location or stand, as they have been designated, is necessarily set far in advance of any preliminary field work at the stand. Therefore, the number of examinations that can be performed at a particular location is dependent upon the number of examining days available. At the majority of locations the number of days available, excluding Saturdays, is 17. At the rate of 12 examinations each day, this provides for 204 examination slots. Examinations are conducted on Saturdays if, for some reason, it is necessary. Because of rescheduling for cancellations or no-shows, the maximum number of youths that is considered for inclusion in the sample is 200. When the number of eligible youths exceeds this number, subsampling is performed to reduce the number to manageable limits. This is accomplished through the use of a master list which is a listing of all eligible youths in order by segment, serial number (household order within segment), and column number (order in the household by age). After the subsampling rate has been determined, every n^{th} name on the list is deleted, starting with the y^{th} name, y being a randomly selected number between 1 and n. Youths who are deleted from the Cycle III sample but who were examined in Cycle II as well as any twin who may have been deleted are, if time permits, scheduled for an examination for inclusion only in the longitudinal study portion or twin study portion of the survey. Their data are not included in the report as part of the regular sample.

Since the strata are roughly equal in population size and a nearly equal number of sample youths were examined in each of the sample PSU's, the sample design is essentially self-weighting with respect to the target population; that is, each child 12 through 17 years old had about the same probability of being drawn into the sample.

The adjustment upward for nonresponse is intended to minimize the impact of nonresponse on final estimates by imputing to nonrespondents the characteristics of "similar" respondents. Here "similar" respondents were judged to be examined youths in a sample PSU having the same age (in years) and sex as those not examined in that sample PSU.

The poststratified ratio adjustment used in the third cycle achieved most of the gains in precision which would have been attained if the sample had been drawn from a population stratified by age, color, and sex and made the final sample estimates of population agree exactly with independent controls prepared by the U.S. Bureau of the Census for the noninstitutional population of the United States as of March 9, 1968 (approximate midsurvey point), by color and sex for each single year of age 12 through 17. The weight of every responding sample child in each of the 24 age, race, and sex classes is adjusted upward or downward so that the weighted total within the class equals the independent population control.

A more detailed description of the sampling plan and estimation procedures is included in *Vital and Health Statistics*, Series 2, Number 43, "Sample Design and Estimation Procedures for a National Health Examination Survey of Children," and in Series 1, Numbers 1, 5, and 8, which describe the plan and operation of the first three cycles of the Health Examination Survey (HES).

Some Notes on Response Rates

As mentioned previously, the sample designs of the second and third cycles of the HES were similar. Differences did occur, however, in response rates of various subgroups of these samples and these differences deserve some consideration here.

Most importantly, the number of youths selected for examination increased from 7,417 in Cycle II to 7,514 in Cycle III. The response rate, that is, the number of youths selected who were actually examined, decreased from 96 percent in Cycle II to 90 percent in Cycle III. Of the examined youths of Cycle II, 13.86 percent were Negro compared with 14.76 percent of those examined in Cycle III. This difference does not reflect a difference in the percentage of Negro youths selected for examination, but in-

stead, a smaller decrease in response rate for Negro youths between the two cycles than was the case for the white youths. In actuality, 13.8 percent of the sample selected for examination was Negro in Cycle III corresponding to 13.5 percent for Cycle II. However, whereas the response rate for white youths dropped from 95.6 percent in Cycle II to 89.1 percent in Cycle III, the response rate for Negro youths dropped a far lesser degree from 98.4 percent to 96.6 percent. Thus, better relative response from the Negro portion of the sample yielded a greater percentage of these youths actually examined during Cycle III than was the case during the previous sample.

Examination of sample sizes in this report clearly shows that at every age group there were fewer girls actually examined than there were boys of the same age. This again is not attributed to differences in numbers of youths selected in the sampling design, but rather to the following differential response rates between males and females:

Age	Male	Female
12	93.5	91.3
13	93.2	91.9
14	91.7	90.7
15	91.6	87.9
16	89.8	87.7
17	87.6	81.8
Total	91.4	88.7

Note that at each age group the response rate for boys exceeded that of girls.

A similar analysis of response rates can be done by age, race, and sex as follows:

Age	White Male	Negro Male	White Female	Negro Female
12	92.6	99.0	90.1	98.9
13	92.5	98.8	91.1	96.8
14	91.0	97.8	89.6	96.2
15	90.7	97.7	86.4	98.6
16	89.2	95.0	86.6	93.0
17	86.5	95.8	80.2	91.4
Total	90.5	97.6	87.4	95.8

The above clearly indicates that for all ages under consideration in Cycle III of the HES, the response rate for Negro youths exceeded that of white youths of the same sex and age.

Reasons for differences in response rates are many but may range from the incentive to get examined in order to miss a day of school, to fear of the examination itself, to inhibitions with respect to being examined. Note that the very worst response rate was recorded for the oldest girls, i.e., 17-year-old females.

Parameter and Variance Estimation

Because each of the 6,768 sample children has an assigned statistical weight, all estimates of population parameters presented in HES publications are computed taking this weight into consideration. Thus, the estimate of a population mean μ is computed as follows: $\bar{X} = \Sigma W_i X_i / \Sigma W_i$; where X_i is the observation or measurement on the i^{th} person and W_i is the weight assigned to that person.

The Health Examination Survey has an extremely complex sampling plan and obviously the estimation procedure is, by the very nature of the sample, complex as well. A method is required for estimating the reliability of findings which "reflects both the losses from clustering sample cases at two stages and the gains from stratification, ratio estimation, and poststratification."[18]

The method for estimating variances in the Health Examination Survey is the half-sample replication technique. The method was developed at the U.S. Bureau of the Census prior to 1957 and has at times been given limited use in the estimation of the reliability of results from the Current Population Survey. This half-sample replication technique is particularly well suited to the Health Examination Survey because the sample, although complex in design, is relatively small (6,768 cases) and is based on only 40 strata. This feature permitted the development of a variance estimation computer program which produces tables containing desired estimates of aggregates, means, or distributions, together with a table identical in format but with the estimated variances instead of the estimated statistics. The computations required by the method are simple and the internal storage requirements are well within the limitation of

NOTE: The list of references follows the text.

the IBM 360-50 computer system utilized at the National Center for Health Statistics.

Variance estimates computed for this report were based on 20 balanced half-sample replications. A half-sample was formed by choosing one sample PSU from each of 20 pairs of sample PSU's. The composition of the 20 half-samples was determined by an orthogonal plan. To compute the variance of any statistic, this statistic is computed for each of the 20 half-samples. Using the mean as an example, this is denoted $\bar{X}_i$. Then, the weighted mean of the entire, undivided sample $(\bar{\bar{X}})$ is computed. The variance of the mean is the mean square deviation of each of the 20 half-sample means about the overall mean. Symbolically, $\mathrm{Var}(\bar{X}) = \sum_{i=1}^{20} (\bar{X}_i - \bar{\bar{X}})^2/20$ and the standard error of the mean is simply the square-root of this. In a similar manner, the standard error of any statistic may be computed.

A detailed description of this replication process is contained in *Vital and Health Statistics*, Series 2, Number 14, "Replication: An Approach to the Analysis of Data from Complex Surveys," April 1966, by Philip J. McCarthy, Ph.D.

Standards of Reliability and Precision

All means, variances, and percentages appearing in this report met defined standards before they were considered acceptably precise and reliable.

The rule for reporting means consisted of two basic criteria. The first criterion was that a sample size of at least five was required. If this first criterion was met, then the second criterion was that the coefficient of variation (i.e., the standard error of the mean divided by the mean $s_{\bar{x}}/\bar{X}$) be less than 25 percent. Thus, if either the sample size was too small or the variation with respect to the mean was too large, the estimate was considered neither precise nor reliable enough to meet the standards established for publications.

In this report, these criteria were met in all instances since the breakdowns used were generally large in size and thus eliminated the problems faced in other reports where subgroups are divided and redivided yielding extremely small cell frequencies.

Hypothesis Testing

Classically, to test the difference between two means (or, put differently, to test whether two samples could have been drawn from the same population), one could set up a test statistic which would utilize the means and standard errors of the means as computed from the samples. The statistic

$$z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{s^2_{\bar{x}_1} + s^2_{\bar{x}_2}}}$$

would then be compared to a table of normal deviates to determine the probability of obtaining values of the test statistic as extreme or more extreme than that computed, if in fact the two population means were equal.

Because of the many breakdowns of the HES sample, innumerable tests of this nature could be performed and, with each new test, the probability of rejecting a hypothesis incorrectly may be .05; but if 10 such tests are performed, the probability of making at least one mistake somewhere in those 10 tests is closer to 0.50. This last "overall error rate" will get increasingly large as the number of such tests increases. Therefore, while the data necessary to do z tests are provided in the tables of this report, no such tests were performed by the authors.

It was decided, instead, to place the greatest emphasis on a relationship remaining constant over both sexes and all ages under consideration. In other words, to say that "all whole year age cohorts of males have greater statures than corresponding age cohorts of females from ages 13 to adulthood" has far greater meaning and interpretability than to say "the mean stature for 13-year-old males is significantly greater (at the .05 level) than the mean stature for 13-year-old females, and the mean stature for 14-year-old males is . . . , etc., as determined by a normal deviate." In these analyses consistency

rather than statements about successions of individual probability levels is the factor considered most important in demonstrating a relationship.

Imputation

The necessity of arriving at a workable imputation scheme for Cycle III of the HES was dictated by the fact that each individual carries a separate and unique statistical weight, i.e., the number of individuals in the United States population he is said to represent. The decision to drop from the sample such an individual due to missing or erroneous values on some number of variables would not be satisfactory unless the statistical weight was somehow redistributed. The extent of bias introduced in this manner would depend upon the scheme chosen for the redistribution of the individual's statistical weight and would carry along with it the major disadvantage of having unweighted sample sizes differ from variable to variable (thus making correlation procedures more complicated) while, of course, the weighted sample sizes would remain constant.

A regression method of imputation which was selected for the analysis of HES body measurements was desirable and possible for several reasons. First, the number of problem cases was small enough so as not to be unwieldy. Second, the various body measurements collected on an individual are highly correlated and, as such, one would like the imputed value to be harmonious with the other valid measures for that individual. To simply impute a group mean or a randomly selected value to an atypical individual in place of either a nonexistent or an existing but obviously incorrect measurement while ignoring the other valid information on that same individual would be undesirable.

Third, the bias introduced by a regression scheme would clearly be less than would arise if individuals with missing or questionable bits of information were excluded from the sample and their statistical weights redistributed. Fourth, this system has the advantage of holding both the weighted and unweighted sample sizes constant from variable to variable thus facilitating any correlations or cross-tabulations desired. Thus, an elaborate regression scheme was utilized to impute body measurements of the third cycle of the HES.

The procedure was as follows: From the total 6,768 subjects on whom some body measurements were performed, 26 subjects for whom there was one or more missing values were temporarily dropped and four files were created from the remaining 6,742 subjects. The files were white males, Negro males, white females, and Negro females. It was from these subjects that the prediction equations were finally developed.

In a typical case, a subject (for example a 12-year-old Negro male) might have a body weight recorded which is so low to raise the question of whether there was an error somewhere in the data preparation process. However, despite this extremely low value, his record would be otherwise complete. Since all the other variables are recorded for this individual, an estimate for body weight is derived based on all the other information available and it is possible to conclude that the recorded measurement is possible considering the youth's other dimensions or that the recorded value is an obvious clerical error and should be changed. Thus, the file with the Negro males who all have complete records is tapped and a stepwise regression is calculated, with body weight the dependent variable. All the remaining variables are eligible for inclusion into the equation with the following restrictions:

(1) Age must be the first variable added into the equation, irrespective of the correlation between age and the dependent variable.

(2) So long as adding a new variable contributed at least .005 (½ percent) to the coefficient of multiple determination (R^2), it was included. If the contribution was less than that the equation was frozen with all the variables which did add at least that much to R^2. (No equation included more than eight independent variables.)

The resulting equation may be of the form

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots \beta_k X_k$$

where Y is the predicted sitting height, α, β_1, β_2, β_3, etc., are the coefficients gen-

erated by the regression, and X_1, X_2, X_3, etc., are the independent variables. By inserting the recorded values for this subject of X_1, X_2, X_3 up to X_k (k being the number of variables contributing significantly to $R^2, k \leq 8$) into the equation, a prediction is arrived at for body weight. A value imputed in this manner is superior to other possible methods since all the relevant information is utilized and allows an extremely large or small person to be assigned a similarly large or small imputed value.

In actuality there were only six youths of Cycle III of the HES whose values for height or weight on the original data tape were either missing or highly questionable.

To determine whether a height, weight, or sitting height was "questionable," extremes of the distributions of each variable were examined case by case. (Although useful, this procedure allows some highly deviant values to go undetected, for example, hidden in the distribution of body weights may be an individual of extremely small stature who had a mispunched weight far too great for his stature but nevertheless within normal bounds for the entire distribution of all weights from the entire HES sample.) But the magnitude of the problem of bad or missing height and weight data in the HES is very small and oversights such as this will not have an appreciable collective effect.

By using the above-described techniques of editing for questionable values and imputing the missing ones, the height values on only two subjects were changed for this report: one youth had no standing height recorded because gross distortion from birth defects made such measurement impossible and unreasonable, and the other youth was unable to stand upright because of leg braces.

A complete description of the problems, the alternatives, and the selected procedure for use in imputation of all the other HES body measurements can be found in a separate document.[19] In addition, a complete log was kept of all changes made on the original Cycle III data and these may be made available upon request.

Quality Control

A detailed discussion of quality control measures has been included in appendix III of Series 11, Number 124. In addition, the analysis of replicate measures of stature and weight was presented. The analysis of replicate measures of sitting height was included in an extensive analysis of all the body measurements used in Cycles II and III in appendix III of the recently published *Vital and Health Statistics* Series 11 report, Number 123.

NOTE: The list of references follows the text.

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